Status of Beam-Beam Compensation with Electron Lenses in Tevatron

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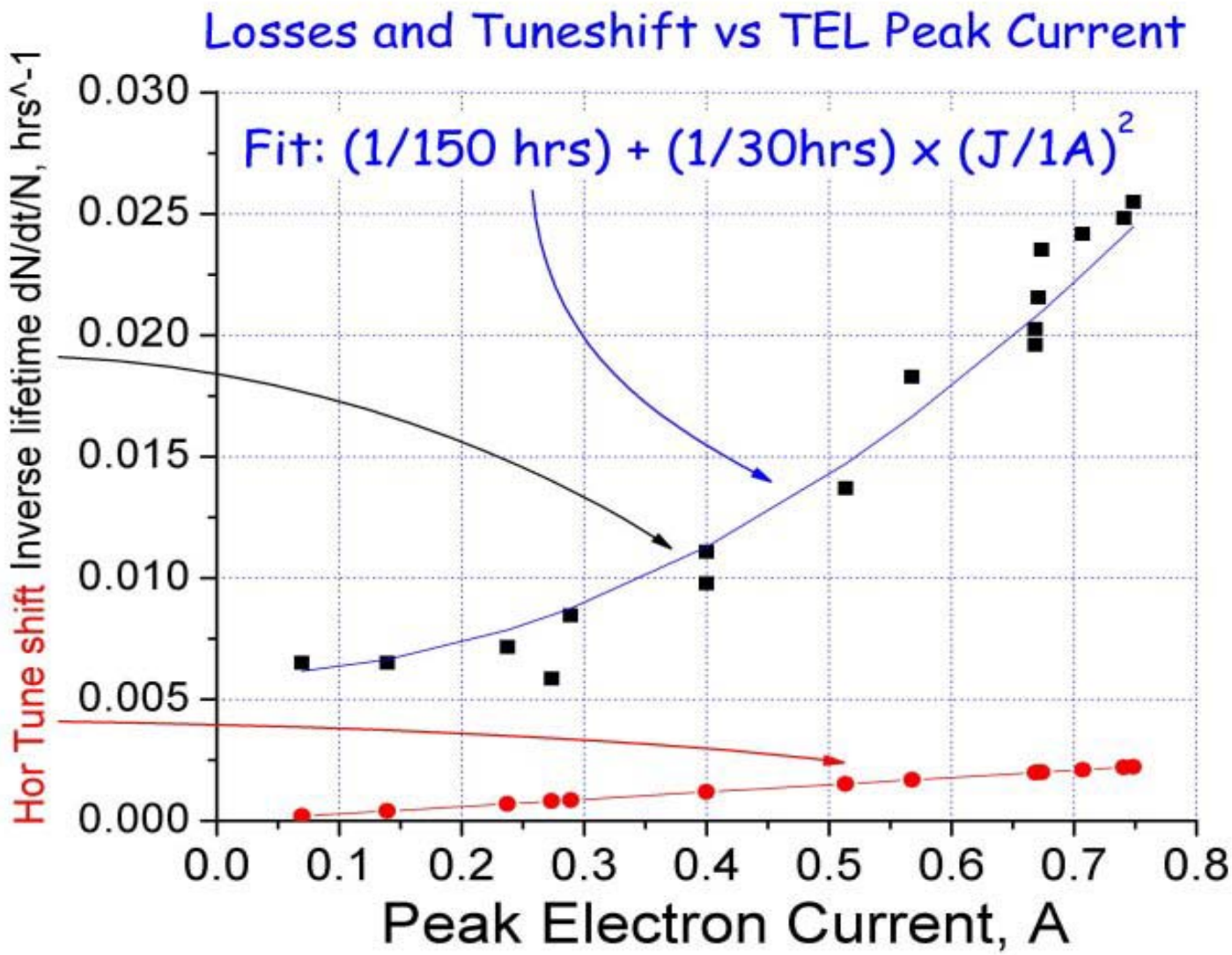
Fermilab

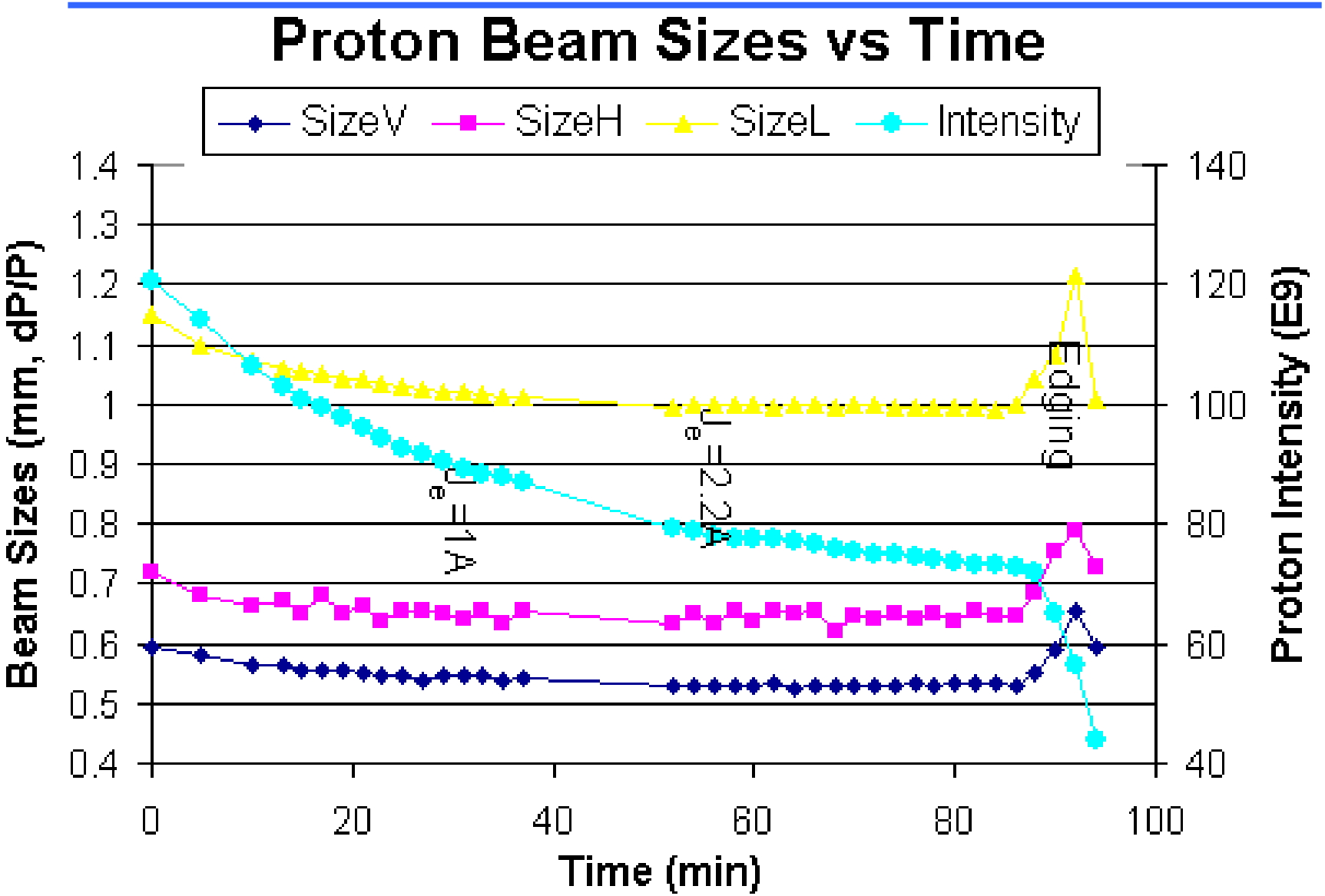
Content

- Sequence of events:
  - TEL-1 installed in 2001
  - max tuneshift dQ~0.009 achieved in 2001-02
  - TEL-1 operational for abort gap cleaning since Jan'02
- Lifetime Issues with TEL → resolved
- First indication of successful B-B-Compensation
- Next steps

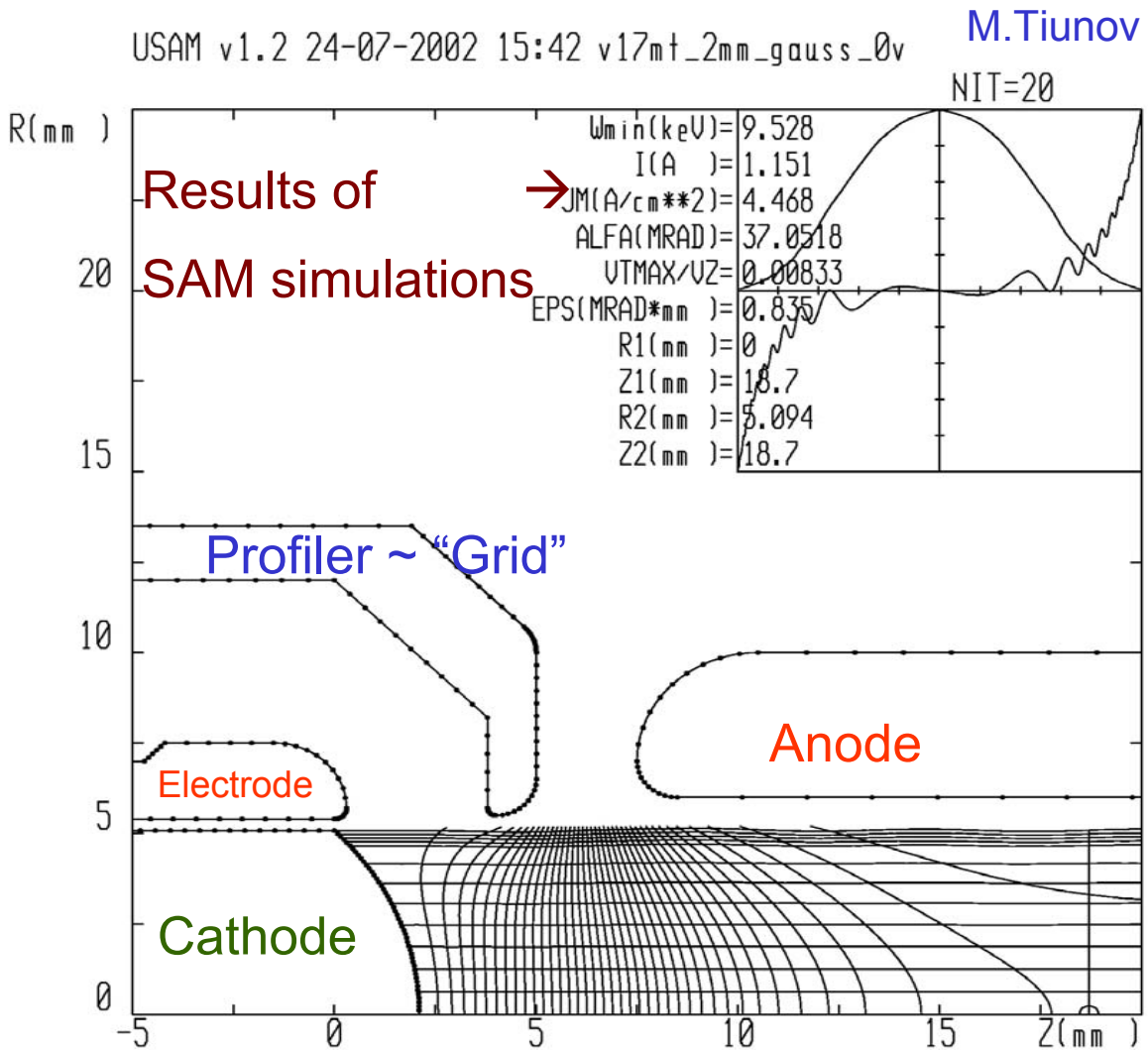
Outstanding Issue with BBC in '01-'02 – limited lifetime



e-beam edge = “donut collimator” A~20p mmrad

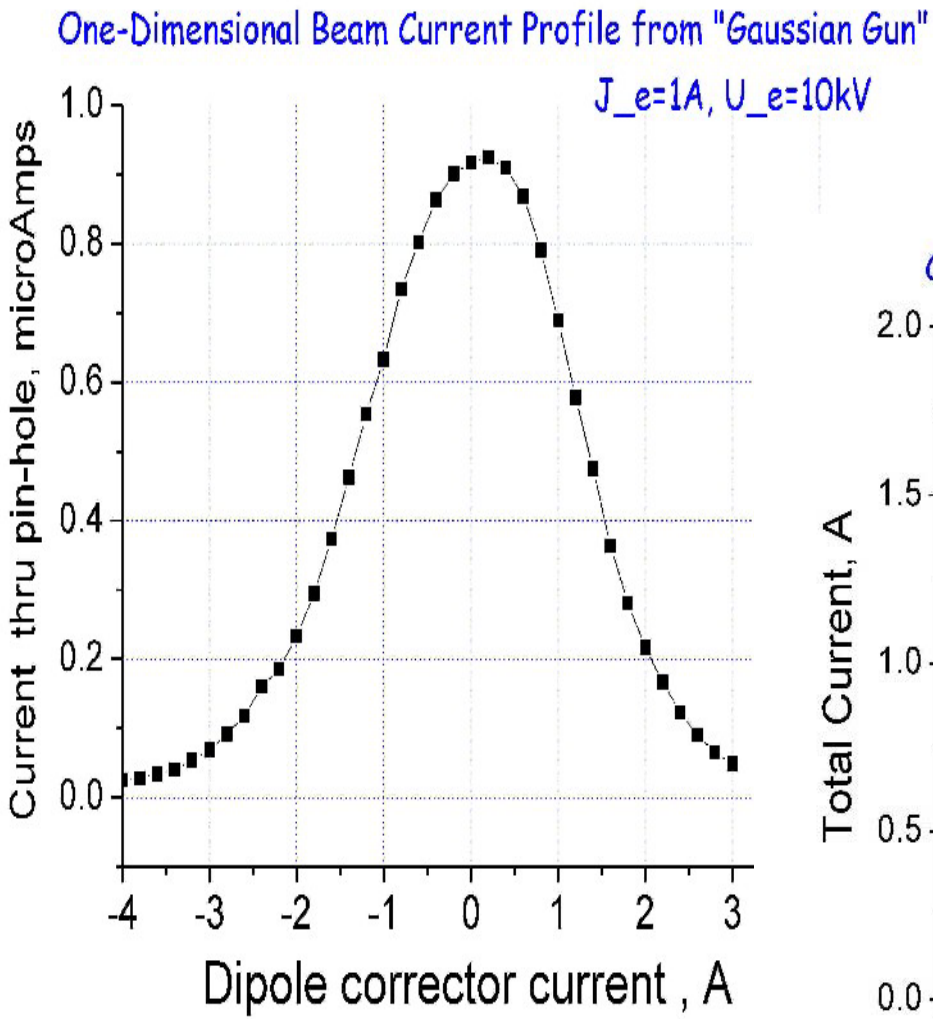


Need of Smooth Edges → Gaussian Gun



- Beam profile controlled by special electrode
- Somewhat reduced current density in the center → need of higher voltage
- Installed in Jan'2003

TEL Gaussian Gun – Installed Jan'03



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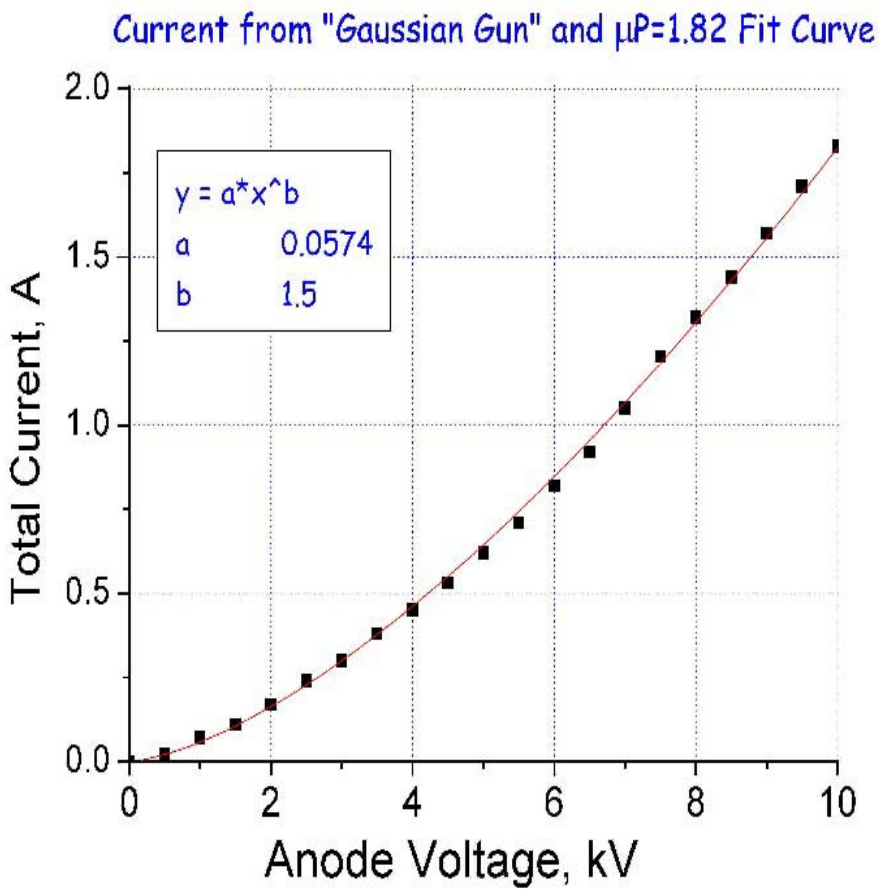
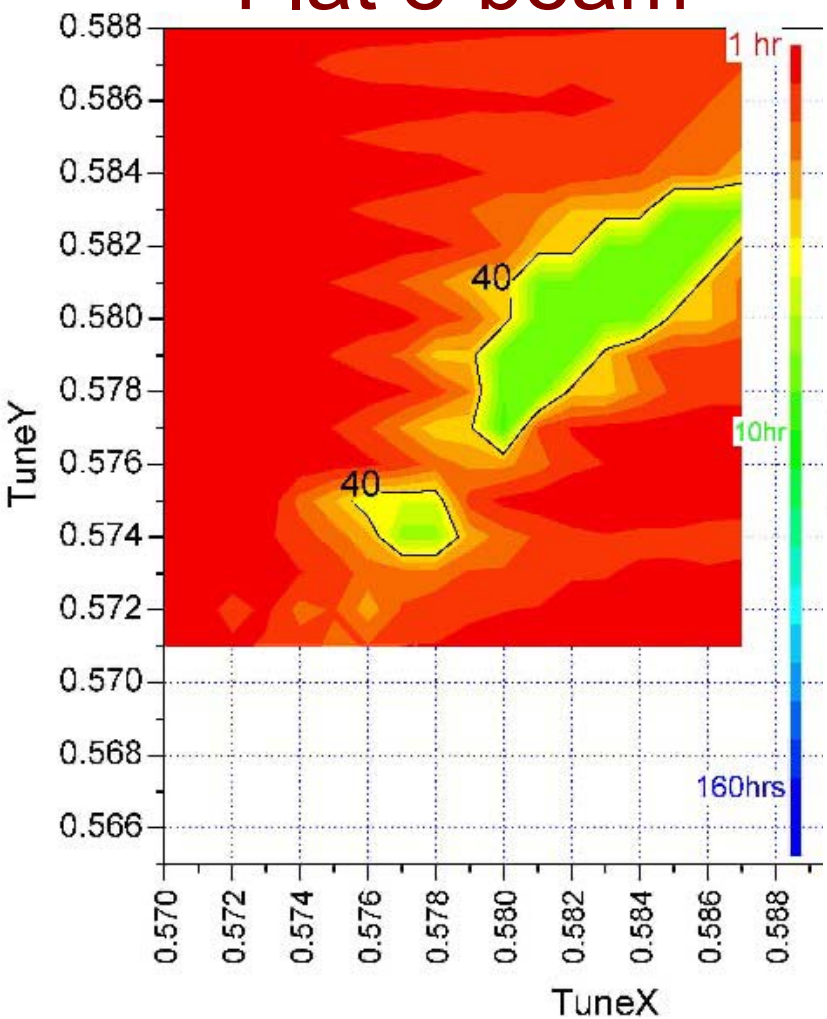
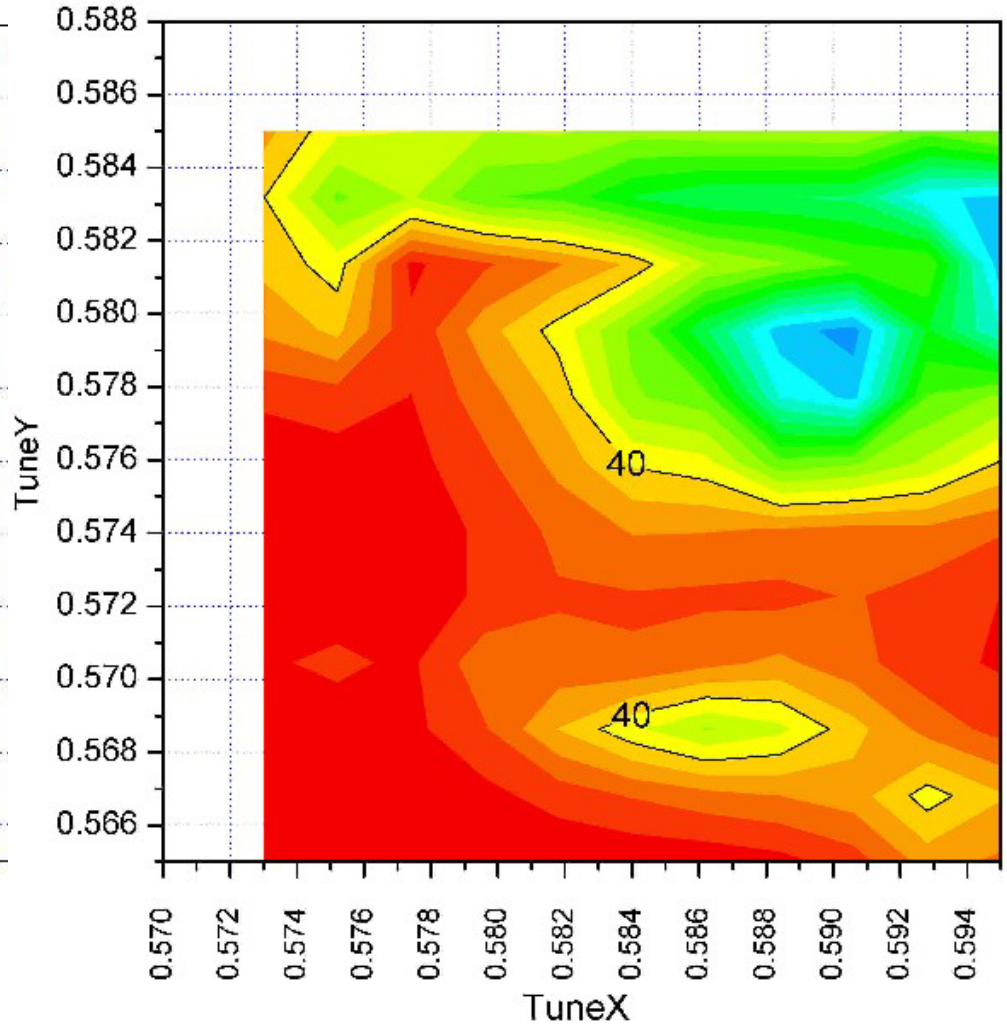


Lifetime vs WP with dQ_{TEL}~0.004

Flat e-beam



Gaussian e-beam



Successful Attempt of BBC with TEL

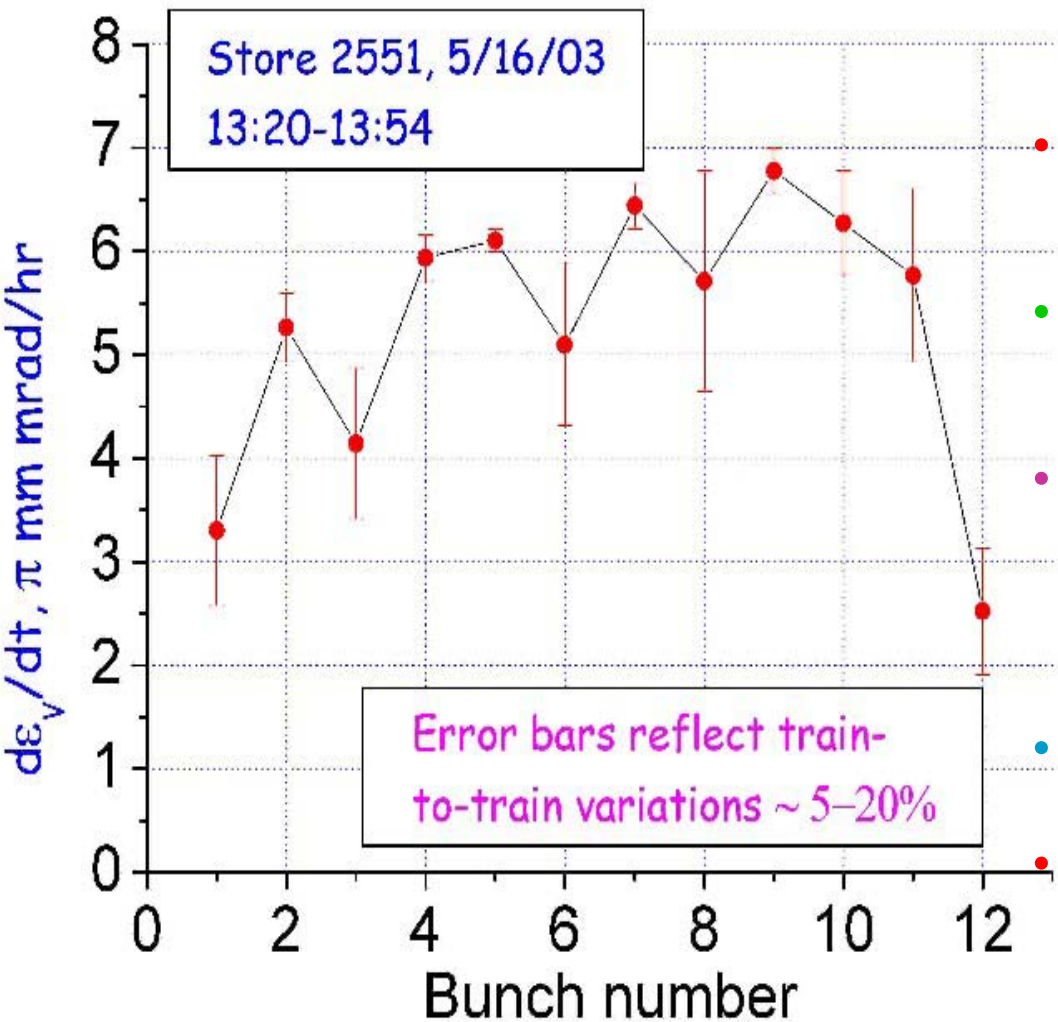
- first, the lifetime improvements with Gaussian gun made sense of the use of the TEL in HEP stores:

  $t_{TEL} \sim$ 100-160 hrs $>$ $t_{pbar} \sim$ 30-50 hrs

- second, it was demonstrated that the TEL can be transferred from DC beam removal regime to BBC regime (includes still manual changes of U_cath, P_fil, triggering from 3/7 to 1/1, timing and pulse width, and use of strong dipole correctors to move e-beam on pbars) and back – with no significant effect on colliding beams or detector backgrounds

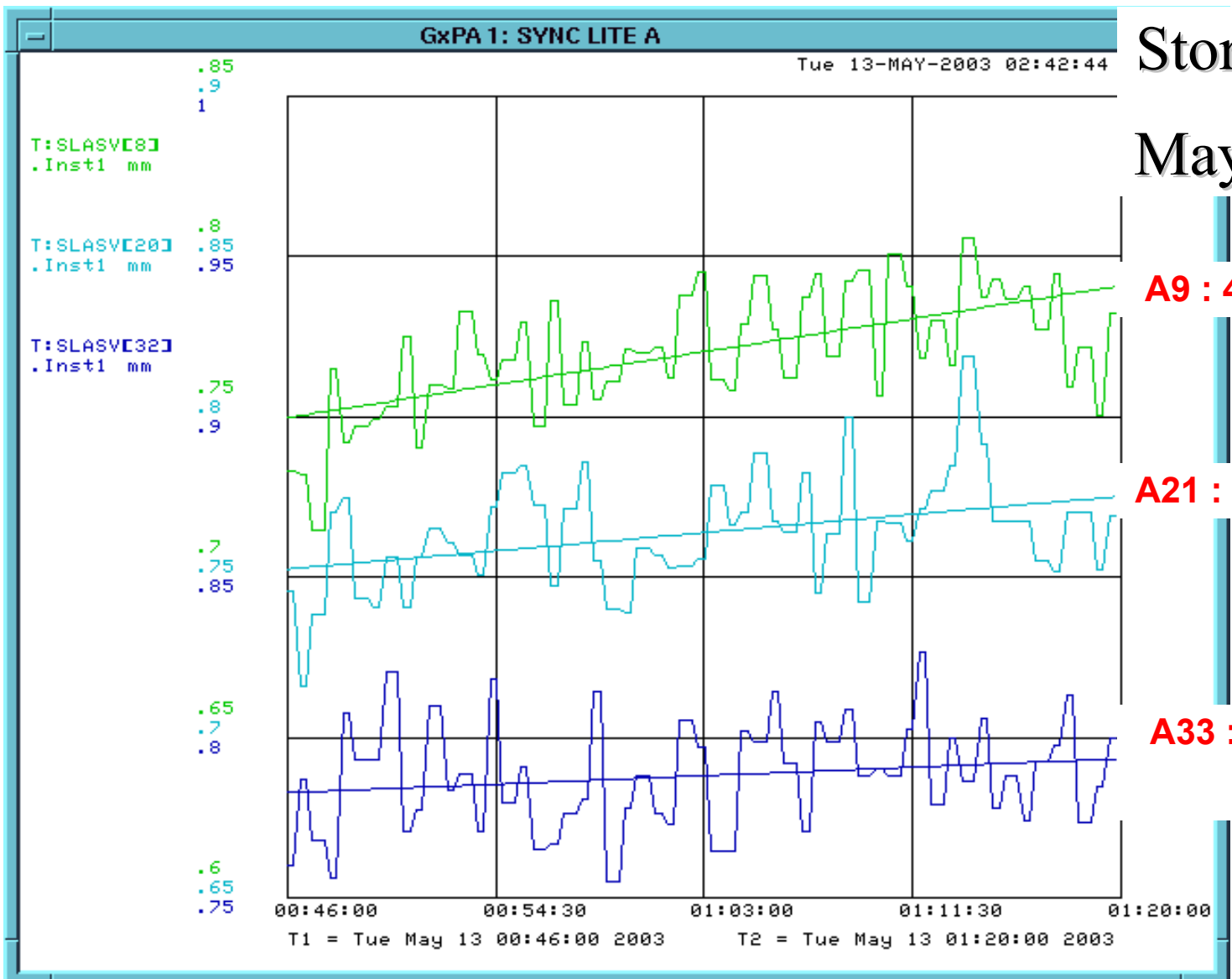
- after that the TEL with some 0.6A of current was timed on single pbar bunch at the beginning of the Tevatron stores and **it was observed that the TEL can slower vertical emittance growth of antiprotons ("reduce scallops")**

Pbar Vert Emittance Growth Rate



- "Scallops" is beam-beam phenomena, they started to occur after Nprotons exceeded 180e9/bunch
- "Scallops" do not take place in every store even with N_p >180e9/bunch
- "Scallops" occur in both planes, but often more prominent in vertical
- "Scallops" seem to be dependent on tunes , e.g. vertical tune change –0.002 can significantly reduce scallops
- Small "scallops" are seen in protons
- Scallops are the same in all three trains of bunches (variations <20%)

Pbar V-Sizes 34 min after p-pbar collisions initiated



Store #2540

May 12, '03

A9 : 4.1 p mm mrad/hr

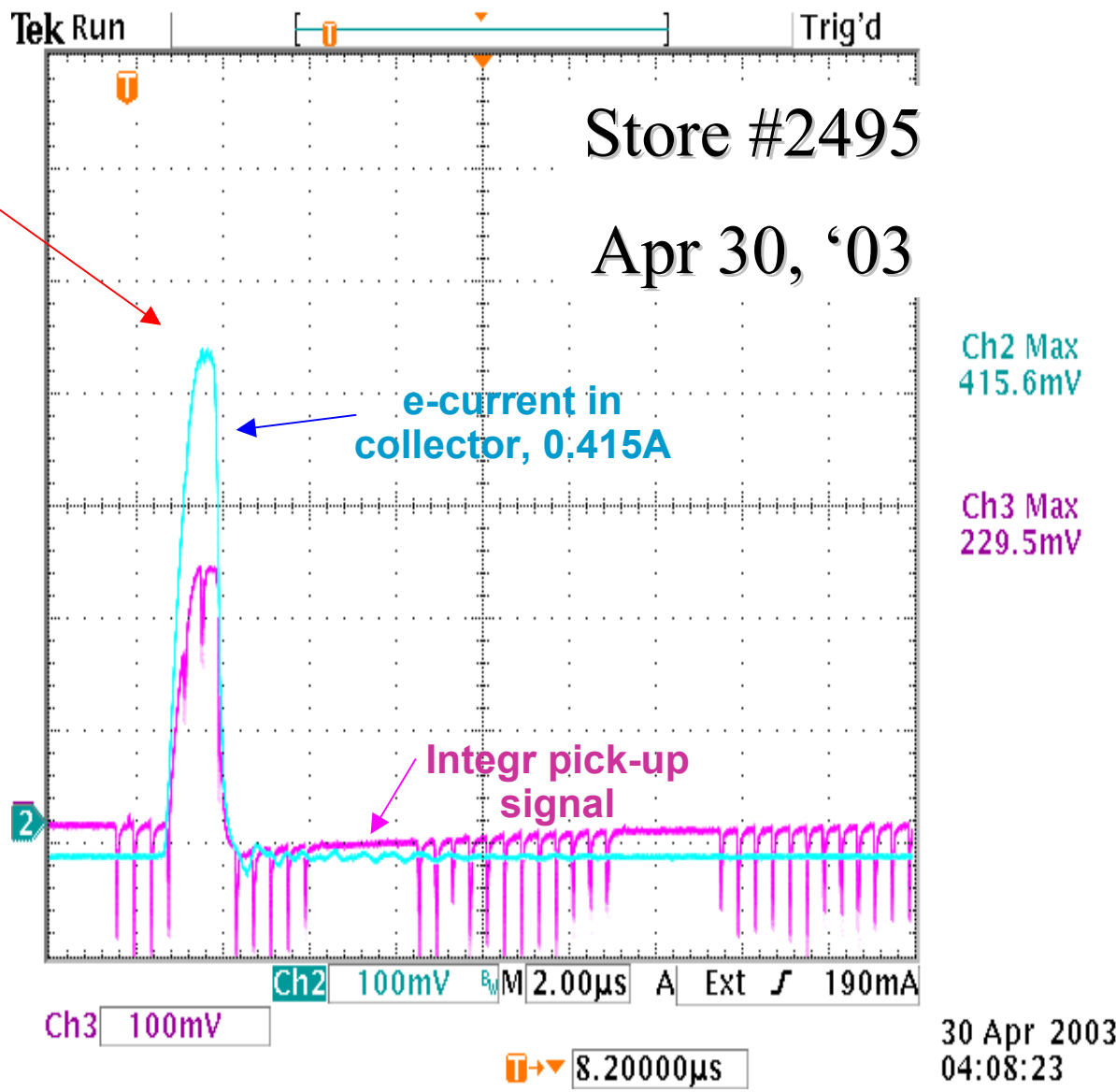
A21 : 2.2 p mm mrad/hr

A33 : 1 p mm mrad/hr

-TEL on it

Statistics of TEL used for BBC

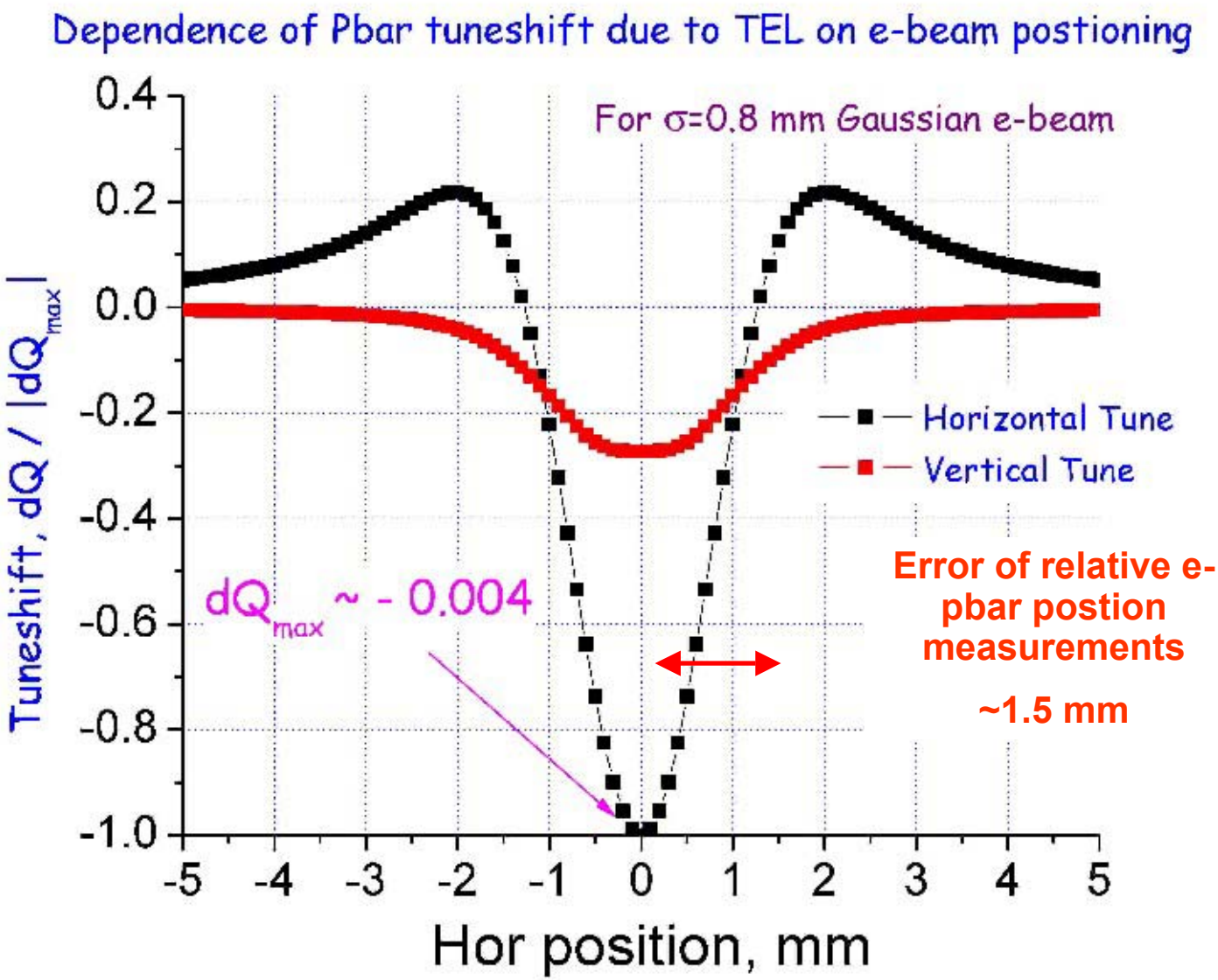
- 8 attempts since 5/20/03
- Neutral or slightly negative effect in two stores #2546, #2549 – but "scallops" occur
- No effect in three earlier stores #2445, #2490, #2495 – no "scallops"
- Positive effect in one store #2540 – "scallops" suppressed
- Faulty pulse generator led to loss of 2 pbar bunches in two stores #2487, #2502



Pbar V-emittance growth rates (p mm mrad/hr)

store	#A9	#A21	#A33
# 2536 (40 min)	9.9	9.2	9.3
#2538 (35 min)	1.9	1.7	2.8
#2540 (34 min)	4.1	2.2	1.0
#2546 (30 min)	3.9	1.9	4.0
#2549 (26 min)	4.5	3.6	7.1
#2551 (34 min)	6.7	6.6	7.0

e-Pbar Alignment Seems to be Crucial



Summary

- Status:
  - max dQ~0.009 tuneshift achieved
  - p(bar) lifetime deterioration proved to be due non-linear beam-beam force at the e-beam edges ("soft collimator")
  - after installation of Gaussian e-gun, p-beam lifetime of ~160hrs has been achieved (compare with 40 hrs in stores)
  - TEL was used in several stores recently and we've got first indications of successful beam-beam compensation : vertical emittance growth rate was reduced for pbar bunch #33 early in store #2540
- Work to do:
  - continue to explore BBC at 150, ramp, LB for both pbar and p
  - improve diagnostics (TEL BPM, Pbar Schottky tunemeter, etc)
  - wider e-beam , better beam current and position stabilization
  - the second TEL is under construction but the BBC is not the major motivation (← spare for the DC beam removal)
  - new HV pulser (~ 15kV instead of 7kV, shorter pulse)
- R&D review Mar'04, TEL-2 decision in Dec'04